Integrated Transport Strategies for Sustainable Development

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Abstract

Metropolitan transportation and land development patterns in most of the world are growing increasingly unsustainable. Many factors point to the need for adoption of a new paradigm for sustainable transportation and community development in both high and low income countries: overpopulation, growing air pollution, limited physical and economic capacity to expand automobile-based transportation systems without community destruction, growing inequality in the distribution of resources, and the urgent need to limit global CO2 emissions to slow the pace of global warming. This paper discusses the new paradigm for integrated and sustainable transport strategies.

A paradigm shift is underway in transportation and community development, analogous to the shift underway in the electric utility sector since the 1970s. There is growing recognition that environmental and economic sustainability suffer from market-distorting subsidies and public policies which favor the most resource-intensive means of transport. The reductionist, supply-side oriented strategies of the past are beginning to be replaced by more holistic approaches that integrate demand-side and supply-side system management with full-cost pricing. Much can be learned by comparing patterns of transport and land development in different countries, noting key factors which have led to dramatic differences in travel demand, mode shares, energy use, and efficiency of resource use to meet social and economic requirements. Emerging information and communications systems technologies will help enable fundamental reforms in integrated transport system management (including systems for automated road and parking pricing and automated vehicle speed limitation) to encourage market-based substitution of high resource efficiency communication and transport modes in place of resource-intensive industrial age transport modes.

Technology innovation will improve the compatibility of motor vehicles with environmental protection and sustainable development, but must be complemented by and harnessed to strategies to manage travel demand. To promote sustainable development in transport we should: (1) preserve and protect modal diversity, just as we protect bio-diversity, recognizing that different modes are needed to most efficiently serve different travel markets with their varying requirements for distance, speed, and payload; (2) understand the underlying activity basis of travel demand and travel choices and use this to explore opportunities for developing long-term least-cost strategies for shaping both travel demand and supply characteristics; (3) explicate the total internal and external long-term costs of transportation choices and move towards fuller cost pricing of transport, removing hidden subsidies, pricing distortions, and incentive/disincentive structures which prevent fair competition between modes and reduce modal diversity and overall community and transport system efficiency and equity; (4) promote institutional and pricing system reforms to ensure better integration and coordination of policies for long-term least-cost community development harmonizing transportation policy with land use, communications, tax policy and education financing, housing, and economic development strategies. This will favor non-motorized transport, substitution of telecommunications for travel, and use of intelligent technologies in surface transportation management.

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Transportation and Sustainable Development

The rapid rise in the number of private motorized vehicles combined with rapid population and urban growth are creating a growing transportation crisis. While motor vehicles are getting cleaner and more energy efficient over time, these benefits are offset by growing dependence and use of motor vehicles. Transportation now accounts for one-sixth of the anthropogenic carbon load to the atmosphere and is one of the fastest growing sources of greenhouse gas emissions. Growth in motor vehicle ownership and use is driven by rising incomes, but is also frequently encouraged by deeply institutionalized subsidies and policies which promote motorization and discriminate against non-motorized and traditional transportation modes.

Despite increased motor vehicle availability, increasing income stratification is leaving behind billions of people, especially in the less developed countries, who in our lifetimes will not enjoy the benefits of personal access to private motor vehicles. Nonetheless, they and their children disproportionately suffer the growing externalized costs related to those vehicles -- health-threatening air pollution and traffic hazards, degraded conditions for walking, cycling, and public transportation, and the disruptive transformation of both metropolitan land use patterns and global climate systems. To promote sustainable development, transportation policies must address not only environmental problems, but also equity and economic sustainability issues.

The primary policy response to issues of sustainability has been to promote supply-side technological improvements. Cleaner fuels, cleaner vehicles, and enhanced inspection and maintenance have resulted in highly cost-effective major reductions in emissions of lead, CO, particulates, and NOx where these have been adopted, particularly in the more technologically advanced nations. Where ever air pollution threatens human health, such measures should be adopted, given their demonstrated cost-effectiveness. Some of these strategies should be immediately adopted as world-wide standards, especially the elimination of lead from motor vehicle fuels, which is needed to avoid permanent neural damage to millions of children. To reduce CO2 emissions, much greater progress can and should be made to increase vehicle fuel efficiency and to substitute alternative means of propulsion while designing and sizing vehicles to better match tailored end uses.

While technological improvements in vehicles and fuels are commonly accepted as appropriate policy responses, there has been growing conflict over the sole reliance on supply-side strategies to deal with traffic congestion and safety problems. Until recently, especially in the US and more automobile-oriented societies, there has been a tendency to think that increasing the speed and capacity of highways was an answer. However, beginning in the 1970s, efforts have been undertaken in many regions to introduce demand-side management of transportation, through changes in pricing, streetspace management and reallocation, land use controls, and improvements to walking, cycling, public transportation, and telecommunications. There is now a growing consensus that it is not possible to "build your way out of the problem," and that trying to solve traffic problems solely with more capacity is like trying to cure obesity by loosening your belt. Many demand side management strategies also offer promise to also address urgent equity and economic sustainability issues. This conflict over supply-side solutions vs. integrated demand and supply side management strategies is at the heart of the paradigm shift occurring in transportation and community planning and system management, and in the reinvention of public sector institutions. Indeed, one can argue that transportation will support sustainable development only by adopting this emerging new paradigm.

Context for the Emerging New Paradigm

The transportation policies of recent decades have been largely shaped by industrial era concepts, grounded in a linear, reductionist, mechanistic, engineering-oriented framework. While useful for the development of superhighway networks, these approaches have been blind to many major secondary impacts of transportation, particularly related to long-term social, economic, and environmental consequences. The new emerging paradigm is being shaped by new insights into complex systems, which more closely resemble biological and ecological systems than machines. The new paradigm draws from a host of sources not available to those who gave shape to the old way of dealing with transportation problems: increased understanding about the properties of self-organizing systems, the mathematics of chaos, catastrophe theory, and fuzzy logic, genetic programming, and advances in consumer choice analysis that recognize the incompleteness of information and the non-optimal non-equilibrium choices made every day by individuals.

Several key problem areas provide a vital context for the emergent new paradigm. (1) large hidden subsidies generally distort current transportation choices in the countries with the most severe transportation problems, (2) inefficient organizations, bloated bureaucracies, and reform resistant institutions frequently impede the renewal of the transportation alternatives needed to expand freedom to choose modes other than the private automobile to meet travel needs, and (3) transportation reform is frequently impossible without addressing broader issues, such as community economic development, housing, land use, zoning and urban design requirements, and both financing and taxation related to vehicles, housing, and educational services.

Transportation Pricing. While some of the costs of road use have been covered by user fees, in most societies, motorists pay far less to drive than the costs they impose on society. This is most clear in countries like the United States, where various studies have estimated the annual hidden subsidy costs at over US$3500 per automobile -- composed of the 40% of road construction and maintenance costs borne by general taxpayers, the several hundred billion dollars a year cost of free automobile parking at workplaces and shops, the significant share of police, fire, and emergency services attributable to traffic functions, the cost of traffic accidents, injuries, and deaths, air pollution related health and productivity losses, and noise pollution. These hidden subsidies encourage consumption of motor vehicle transportation at a higher level than is economically optimal and reduce opportunities for other transportation and communications modes to compete in a market-based system. Transportation subsidies, while stimulative of short term economic growth, reduce the long term sustainability of development patterns by encouraging higher levels of resource consumption. In the absence of such subsidies, there is little doubt that we would see major changes over time in the location decisions and travel behavior choices of individual households and firms favoring greater proximity, more walking, bicycling, and use of collective transport modes, and telecommunications.

Transportation Service Management. However, price signals are not the only determinant of such choices. Private motor vehicles have also been more responsive to market opportunity than public transport. In much of the world, public transportation systems have been hard pressed to modernize and expand to meet growing travel demand and to respond appropriately to the differentiation and evolution of niche markets. Often ineffective and unresponsive public sector management, excessive regulation, rigid labor agreements, and other factors have combined to reduce productivity, impede innovation, and restrict access to capital for reinvestment, adaptation, and growth in public transport. With less regulation and a generally more decentralized structure, private motor vehicle based transport systems have generally been more flexible in quickly responding to emergent market needs. For public transport to avoid further decline, de-bureaucratization and other reforms are needed to promote entrepreneurial service development. In many cases, this will require development of new paratransit firms to provide more demand-responsive niche services at a price sufficient to generate modest profits. Such reforms would be greatly facilitated by creating a more "level playing field" for competition by reforming the pricing system for private motorized transportation use.

Transportation Network Allocation and Land Use Management. The allocation of street space and patterns of land use and urban design are also powerful factors influencing location choice and travel

behavior. In much of the world pedestrians, bicyclists, and public transportation vehicles have lost access to street space they once dominated following periods of rapid motorization. In some countries, such as Japan, the Netherlands, Denmark, and parts of Germany and Scandinavia, government policies have provided some protection for these spaces, preserving a vital role for non-motorized and public transport modes. Without such protection, the quality of non-motorized and public transport modes declines in both absolute and relative terms and those who can afford motorized private transportation abandon their old ways of travel and take up the new more costly and higher status mobility of the motorcycle and motor car. This in turn drives a reconfiguration of the community, as motor vehicle accessibility demands sprawled development with parking and high speed access, destroying the older patterns which were based on clustered mixed use patterns enabling pedestrian accessibility and proximity to public transport. In the classic American pattern, as growth follows the money, new developments spring up in the new automobile-oriented patterns, leaving the earlier centers behind as decaying cores increasingly occupied by the poor, the young, and the very old.

Like a rainforest with its complex ecological web, which collapses quickly to the chainsaw, the complex webs of non-motorized and public transport access systems frequently collapse in a short time beneath the wheels of fast and powerful motor traffic. In both rainforests and transport systems, following collapse, there is no easy way to regain the diversity and complexity which has been lost. Loss of this diversity comes at a great cost in terms of systems efficiency. **(1)** When there is only one primary transport mode available to serve mobility needs, individuals are denied the opportunity to choose from the missing transport modes which might have satisfied the need with lower resource utilization. Americans today frequently have no choice but to drive even to make the shortest of trips, because street designs and land use are designed solely for driving, admitting no place for the pedestrian or bicyclist. Indeed, a basic human right -- to be able to walk safely where one lives -- is in danger of being lost in many communities. The capillary system of movement in many communities has been designed out of existence, forcing all movements into resource and capital intensive transport.

Indeed, we have reached a zenith. In American cities on average, fewer than 5% of trips are made without recourse to a motorized vehicle -- half the share of trips in 1960. By contrast, in European and Japanese cities, 20-50% or more of all trips are made by walking and bicycling and the bicycle is the predominant mode of access to express transit services in suburbs, serving a quarter to more than half of all access trips and a significant share of trips from stations to nearby workplaces and schools. Even while undergoing substantial growth in motor vehicle ownership, Europe and Japan have sustained non-motorized and public transportation choices for their citizens.

The policies of European and Japanese local governments have better recognized the need to preserve a balance between modes and to link transportation and land use policy. As a traffic policy paper of the League of German Cities noted several years ago, "Public mass transit and individual transport, either on foot, by bike, or in a car, must be seen as a holistic system. Each mode needs to be promoted where it offers the greatest advantage in economic, environmental, and social terms. With the help of development policy decisions, building and traffic regulations and associated planning measures, we must help achieve a reduction in transport that is avoidable and shape the unavoidable traffic in a manner that improves the living and environmental conditions of our citizens." **(2)**

The Netherlands and Denmark stand out as models of integrated multi-modalism with sound land use planning. In both countries public transport and bicycle use fell dramatically in the 1950s and 1960s with suburbanization and rising investment in roads and automobiles. Starting in 1975, it became Dutch national transport policy to devote at least 10 percent of the surface transportation budget to bicycle facilities as a way to reduce the expenditures for public transport subsidies and roads, while favoring the environment and urban quality. Today, more than 30 percent of all trips in the Netherlands and 25 percent of all access trips to railway stations are by bicycle. In Denmark, car owners pay a nearly 200 percent sales tax when purchasing a car, approximately US $1000 per year in automobile registration fees, and US $1 a liter for gasoline. Much of the tax proceeds benefit public and bicycle transport. Copenhagen installed cycle paths along a large portion of the major roads throughout the city in recent years and reversed the decline of bicycle use, which now accounts for over one-fourth of all trips in the city. By effective integration of low and high technology transportation strategies, European

and Japanese cities and suburbs have developed highly efficient mobility systems that may offer long-term competitive advantages over the increasingly unsustainable automobile dependent U.S. pattern. Indeed, residents of American cities use 4.5 times more gasoline per capita than residents of typical European cities and 10 times more than residents of typical higher income Asian cities. **(3)**

Many forces lie behind these differences, but there can be little doubt that recent patterns of growth and transportation system development and management are increasing U.S. automobile dependence and exacerbating these problems. Research in the Washington, DC area by Bruce Douglas suggests that firms located in a suburban edge city typically account for twelve times as many employee automobile trips during the day as firms located in a major central city. Trips made by foot or transit in central cities must be made by automobile in the edge city, where sidewalks are lacking, crossing the street is difficult, and where typical day-time destinations are dispersed. Yet more than three-fourths of employment growth in most U.S. metropolitan areas in the past decade has been in the suburbs, typically in automobile oriented edge cities. Two thirds of American office facilities are in suburban centers and 80 percent of these have been developed in only the past two decades. It is no wonder that automobile dependence has grown.

The costs of automobile-oriented sprawl impose a significant drag on economies over time and pose problems for government finance. Research has shown that typical American low density sprawl generates capital costs nearly double that of high density planned development, in addition to using much greater amounts of energy and water and producing much higher amounts of air and water pollution. **(4)** At the same time, existing infrastructure in older communities is frequently underutilized. A 1979 study by the Los Angeles County Transportation Commission estimated that Los Angeles motorists spent $4 billion annually on gasoline and that a 10% reduction in gasoline consumption would boost the local economy by $500 to $700 million per year. For every dollar spent on gasoline, the local economy lost between $.33 and $.50, despite the presence of regional refineries. This was compounded by the difference in economic multipliers for expenditures on petroleum (1.8) compared to general goods and services (2.7). A 1985 energy study by Montgomery County, Maryland, found that only $.15 of every dollar spent on gasoline by County residents remained in the regional economy. The smaller local share compared to LA can largely be explained by the absence of refineries in the local economy. **(5)**

Demand-Side Management: What is the Potential?

Recognizing the problems of overdependence on the automobile, transportation demand management (TDM) has won increasing attention in the U.S. However, reviews of TDM strategies have frequently indicated that traditional strategies -- such as construction of new capacity for high occupancy vehicle lanes (HOV), park-and-ride-lots, and the modest expansion of public transportation -- have very limited effects in reducing vehicle travel demand. These traditional American strategies have been an add-on to supply-side oriented transport planning and management systems. They have focused on work travel, long trips, and peak-period travel, which composes a declining share of total travel -- now less than 30% of trips. Some have cited low performance to date as evidence that TDM has little promise and that we should thus get on with expanding road capacity while cleaning up vehicle technology. However, this lack of impact should come as no surprise given the small magnitude of the measures considered and the context in which implementation has been occurred.

Studies in the San Francisco Bay Area of California estimated that conventional TCMs would reduce mobile source emissions by 1-3% without major new funding, but with major new funding, it would be possible to achieve a 20-30% drop in work vehicle travel with an associated 5-8% reduction in total daily vehicle trips and vehicle km of travel (and associated emissions), with a program involving aggressive transit expansion and a host of ridesharing incentives, at a cost of perhaps $100 per capita per year. Adding to this more rigorous performance criterion (or the parking charges and monetary incentives likely to result from such criterion) would likely boost mobile source emission reductions to 7-10%. **(6)** Supportive zoning changes to increase density and assure mixed use development around transit stations could increase these values considerably over time. There is a great

deal of synergy between demand management strategies. In an environment where automobile use is heavily subsidized, where it is unsafe to walk or bicycle, where parking is free and oversupplied, and where sprawled rather than clustered development is encouraged, it is not surprising to find that substantial spending on transit services results in little immediate impact on traffic congestion, mode choice, or air pollution. Indeed, many critics of transit have found it easy to identify circumstances in America in which transit investments, especially in lower density areas, are not very cost-effective.

A number of potential non-traditional TDM strategies, such as those dealing with short trips, non-peak period travel, and non-motorized modes, have thus far been overlooked or discounted without serious analysis by most U.S. transportation planners, despite their widespread use in many northern European countries and selected American and Canadian cities and towns. The addition of non-traditional TDM measures and stronger pricing incentives, combined with effective land use management programs could be anticipated to reduce pollution and energy use in American communities by 15-25% over the course of the next decade, compared with current plans and programs, effectively countering current trend forecasts of 2.5% annual growth in vehicle km of travel. **(7)** Areas anticipating significant growth now planned in a highly automobile dependent sprawled pattern face major opportunities to channel their growth into more efficient patterns that will lower, rather than raise the regional average of vehicle km of travel and vehicle trips per household and per job. Areas anticipating slow growth will need to rely more on pricing measures, retrofitting of existing neighborhoods for pedestrian and bicycle friendliness, telecommuting, parking management, and transit/paratransit improvements to shape travel demand. Such changes could help metropolitan areas to channel their growth into more economically efficient patterns that will enhance their economic competitiveness.

Towards Integrated Transport System Planning and Management

To be effective, demand side management cannot be just an add-on to conventional supply-side highway capacity strategies, but must be translated into a framework for integrated transport planning and system management. In this new framework, supply-side technology fixes and demand-side approaches should be designed to work together for efficient goal-directed management of surface transportation and community systems. Economic and environmental sustainability should be key goals, with an emphasis on meeting economic and social needs for access and mobility with the most efficient use of non-renewable resources and with increased equity. What might this entail?

Intelligent Transportation and Smart Communities. Recent advances in information and communications systems make it possible to introduce "smart" systems into surface transportation at relatively low cost compared to potential benefits. These could take several forms.

Automated electronic road and parking pricing, using smart card technology, promises to soon revolutionize the financing of highways and make it possible to recover from users the internal and external costs, including congestion costs, of private motor vehicle operation, without the delays and inefficiency of traditional toll booths. Already such systems are coming into limited use in Norway, Singapore, and elsewhere. Electronic pricing systems could be introduced gradually -- one lane at a time or one facility at a time -- and all new vehicles could be required to possess appropriate smart cards and "black boxes." Political support could be expanded by refunding the potentially substantial revenues from road pricing back to the residents of the community, whether they drive or not, in the form of direct transfers or reduced taxes. While the dividends of the large past public investment in highways is now largely paid in direct proportion to how much a person drives on the roads, this system could redistribute these dividends more to those who drive less.

Smart technologies could just as easily be used to automatically limit the speed at which vehicles are driven within certain areas or on certain roads through use of electronic speed governors. This could allow electronic traffic calming, smooth traffic flows on arterial roads where traffic signals are coordinated, and manage high speed related emissions and safety problems on motorways, reducing traffic deaths and injuries. Such systems could help in reallocating and then managing street space to

expand the market potential for smaller, lighter weight, lower speed and lower performance high-efficiency electric, flywheel, and hybrid neighborhood vehicles. Commercialization of such vehicles, which could be closely tailored to their end uses, could cut CO2 emissions for a major share of vehicle trips by up to 90 percent, based on recent research at the University of California/Davis by Sperling and DeLuchi.

Smart technologies are already making public transport more attractive in many European and Japanese cities, with real-time passenger information, traffic signal preemption, and dynamic routing. Further promise lies in real-time paratransit system management for ride-sharing. Information and communications systems have already begun to complement and at times replace the need for travel, expanding opportunities for telework, teleshopping, and global collaborations. Such systems could also be used to better manage production logistics and intermodal transfers in a world moving towards fuller-cost transport pricing.

Cashing Out Subsidies and Unbundling Prices. It is no doubt a political challenge to begin charging for thing which have in the past been free or highly subsidized, as the Dutch have recently noted in backing away from a road-pricing scheme. However, there are other ways to approach the problem of pricing.

Automobile insurance is now typically paid as a lump-sum which varies little based on the distance driven or number of trips taken. Legislation is pending in several parts of the U.S. to develop "pay-as-you-drive" automobile insurance, which would be paid in part at the gasoline pump, with revenues distributed back to insurers based on the policies they write, with a much smaller part of the premium paid in an annual lump-sum adjustment. This would reward those who drive less with lower insurance costs. Smog fees or "feebates" based on the distance driven and the rate at which a vehicle pollutes are another mechanism for charging those who drive more polluting vehicles and who drive more and transferring some or most of these revenues to reward cleaner and less consumptive travel behavior.

Parking is frequently offered by employers and retail shops as a free benefit, with the price bundled into the wage package or the cost of goods. However, if given a choice about how to "spend" their subsidy, many individuals would choose to take the money and forego the parking. California has recently adopted a "parking cash-out", now proposed as national legislation, which would create just such a choice. Employees would be able to use the subsidy to pay for parking, use it to pay for public transport, or receive it as added income. To deal with free parking at shops, in many locations it would be practical to introduce a charge for parking but to offer shoppers a rebate exchangeable for purchases, rewarding those who arrived without driving a motor vehicle. Building and housing leases and purchases frequently come bundled with automobile parking, which cannot be refused. Legislation could require the unbundling of these transactions, ensuring that the market value of parking spaces would be recognized at time of purchase or lease.

Intelligent Intermodal and Public Transport Management. There are many opportunities for making public transport more efficient and attractive. Curitiba, Brazil, has shown how busways can deliver very high productivity, with 25,000 passengers an hour or more. The introduction of low-cost transit "tube" stations, which separate fare collection from vehicle loading and unloading, dramatically reduces the amount of dwell time of vehicles in stations, since wide front and rear doors can be used for boarding and alighting.

Paying attention to intermodal opportunities can also offer large benefits for both passengers and freight. For example, in the early 1970s, the Ramo bakery delivered products direct from the factory to 60,000 small shops in Bogota using 135 trucks, which often operated with partial loads and had trouble parking near their deliveries. The bakery changed its distribution system so that a much smaller fleet of trucks were used haul products to satellite warehouses, where a fleet of 900 cargo-tricycles picked up the baked goods for final delivery. Total costs of the delivery/sales system dropped by two-thirds from their previous level through this intermodal integration and differentiation while increasing employment. **(8)** This type of transport system refinement for sustainability, where a single mode is replaced by a combination of modes to accomplish a transportation task more efficiently, is needed in

cities and countries around the world.

An analogous combination in personal transport is bike-and-ride systems. Hundreds or thousands of bicycles are found parked at railway stations in many cities in China, India, Japan, and Europe, where the predominant means of access to express railway stations is typically the bicycle. Such systems can expand the market area for stations at both home or work ends if secure bicycle parking is available and if it is safe and feasible to cycle in the surrounding area. Bike-and-ride system development is an important sustainable strategy for large cities with long average trip lengths and can significantly expand the reach of both the bicycle and the public transport system. **(9)**

Street Space Management. Reallocating street space to pedestrians, bicycles, and public transport has been a key element in strengthening many urban centers. Traffic cells, which restrict through and cross-center movements by private car while permitting full access to non-motorized and public transport, have demonstrated strong positive benefits in a number of Japanese and European cities and suburbs, such as Houten and Groningen in the Netherlands, and have even fared well in a handful of communities in America, such as Davis, California. Portland, Oregon has shown how creating an extensive downtown transit and pedestrian zone with transit right-of-way dedicated on main streets can restore and retain a vibrant downtown retail and cultural core even in America in the 1980s. The widespread success of traffic calming strategies in Europe, Japan, Australia, and selected US communities are another strategy for adapting automobile-oriented streets to multimodal uses at low cost.

Conclusion

Developing integrated transport planning and management systems will require new ways of thinking about community and national circulatory systems. Much can be gained by investing in improved information and monitoring to assess system performance and to increase the rationality of pricing, investment, and streetspace allocation policies and to harmonize these with new vehicle types more tailored to end uses, such as small neighborhood electric vehicles. New analytic tools offer promise for developing long-term least cost evaluation and planning approaches, similar to those developed for the electric utility sector in the 1980s. The potential payoffs in more productive investments and more efficient use of resources are far greater than the cost of blindly expanding highway capacity to meet unconstrained projected demand. Indeed, now is the time to learn from the wise Iroquois chiefs of North America, who were always asked when making important decisions to consider the impacts of their actions on the seventh generation. The future of our children depends upon it.

References

(1) Michael Replogle (1989), "Transportation Strategies for Sustainable Development," *Proceedings from the 5th World Conference on Transport Research*, Yokohama, Japan, July 1989.

(2) Cited in Dr. Hans Pflaumer, "Traffic Concepts for the City of Tomorrow: A German View," *ITE Journal,* July 1988, p.47.

(3) Kenworthy, Jeff and Peter W.G. Newman, "Learning from the Best and the Worst: Transportation and Land Use Lessons from 32 International Cities with Implications for Gasoline Use and Emissions," *Conference Proceedings from Livable Cities for Florida's Future*, May 1988, Governor's Energy Office, Florida DOT and City of Gainesville, p. 27-54 (reprinted from proceedings of the 8th Annual Pedestrian Conference, Boulder, CO).

(4) Real Estate Research Corporation, *The Costs of Sprawl,* U.S. Environmental Protection Agency, 1974, Washington, DC. Table 3, p.9.

(5) Los Angeles County Transportation Commission, *Transportation Energy Conservation in Los Angeles,* November 1979; Montgomery County Department of Environmental Protection, *Montgomery County Energy Study*, Rockville Maryland, 1985.

(6) Greig Harvey and Elizabeth Deakin, "Air Quality and Transportation Planning: An Assessment of Recent Developments," *Searching for Solutions: Transportation and Air Quality,* U.S. DOT/Federal Highway Administration, Policy Discussion Series No.5, August 1992, Washington, DC, p.5, 28.

(7) Michael Replogle, Transportation Conformity and Demand Management: Vital Strategies for Air Quality Attainment, Environmental Defense Fund, April 1993, Washington, DC.

(8) Ricardo Navarro, Urs Heireli, Victor Beck, *La Bicicleta Y Los Triciclos,* Centro de Estudios en Tecnologias Apropiadas, Santiago, Chile, 1985, p. 37-64.

(9) Michael Replogle and Harriet Parcells, *Linking Bicycle Pedestrian Facilities to Transit*, US Federal Highway Administration, National Bicycling and Walking Study, Washington, DC, 1993. and Michael Replogle, *Bicycles and Public Transportation: New Links to Suburban Transit Markets,* Institute for Transportation and Development Policy, Washington, DC, 1984 (2nd printing 1988).